Teletype Corporation ASR-33 on display at the Computer History Museum. It was widely used as an inexpensive input/output device in the minicomputer era. (Photo by Arnold Reinhold)

APRS and other Digital Communications: Part I

Cory GB Sickles WA3UVV

While many hams may think of APRS as a mode that has little more to offer than beaconing and radiolocation functions, it is a figurative Swiss Army Knife of utilities that can be of use in contacting other hams while traveling, exchanging quick text messages, satellite communications, email, public service, and many other activities. Come explore the various facets of APRS and other non-verbal digital communications. You might well find something new to pursue, as a radio amateur.

Digital communications have been a part of amateur radio since its inception. While I want to get you excited about the possibilities of APRS (Automatic Packet Reporting System), I think it is also important to give you some background on the history of digital communications. That way, you should end up with a good foundation on what many of the terms are and just how we got here.

When early radio first took to the air – more than a century ago - the emission used was generated by spark gap. In most cases, the spark was triggered by rotation of a motor, with numerous make/break connections of moving parts and high voltages. The more contact points and the faster the motor's RPM (revolutions per minute), the higher the frequency of the spark emissions. The use of an automotive ignition coil might also be employed.

Radio – at this point – was a mechanical contrivance. What controlled whether voltage was flowing to the contacts was typically a rather hearty version of the telegraph key. Thus, the means by which spark communicated was Morse code. As (1) the dits and dahs of the code can be thought of as single or multiple bits in a data stream and (2) that it was controlled by a finger – such transmissions were the first "digital" communications.

Thankfully, electronics entered the scene, the emissions became pleasant sounding continuous waves (CW) of energy and the ability to receive Morse code signals was much improved. By comparison, spark generated dampened waves, which added another challenge for the operator having to receive them. From this comparison, you now know why code is commonly referred to as "CW."

In another area of interest, a gentleman by the name of Frank Pearne began experimenting, with the goal of creating a printing telegraph. After gaining financial support from Joy Morton – the head of well-known Morton Salt – he was not making sufficient progress and Pearne eventually lost interest. Through the efforts of several other gentlemen with various goals – well documented at **www.thocp.net** – a direct printing means of encoding and decoding asynchronous characters was developed and the Teletype Corporation was formed.

Note that this did not use Morse code in any fashion. A new code had to be developed that could reliably be sent and received. The teleprinters used QWERTY keyboards (with a few extra keys), synchronous motors, cams, relays, and other mechanical parts as make/break connections that controlled a print carriage with multiple strikers to print out the typed characters.

Initially, the paper was a continuous roll of thin-gummed strips that would be passed through a water bottle with a sponge, cut to length and pasted onto a page. If you have ever seen old movies where someone gets a telegram and there is a close-up shot for you to read, you have seen what the end results looked like.

Eventually, the means to print with a stationary platen and moving basket – the opposite of most manual typewriters – was developed. Also, the means to punch and read wide paper tape with holes, gave the technology a way to store and re-broadcast information.

This code used five bits for each character, with a "start" bit of the same duration, plus a trailing "stop" bit that was (for mechanical concerns) a little longer – at 1.42 bits – often expressed as 1.5. With five bits, there are 32 possible characters, but that is not enough for the entire English alphabet, numbers, special characters ($,#,!...), and control characters (Carriage Return, Line Feed, space…). So, two characters were dedicated to the function of shift and unshift, by which the print carriage would be physically moved, so that additional characters would be printed – in the same way a [Shift] key is used on a typewriter. These characters are known as "FIGS" and "LTRS," for figures and letters.

This allowed for almost twice the number of characters, but still not enough for both upper and lower case. While lower case is more distinct and faster to read, it was decided to standardize on upper case, in consideration of proper names – especially GOD.

These compromises allowed for a lower cost in building the teleprinters, plus a higher speed of resultant characters or words per minute (WPM) – a term we will return to in a moment.

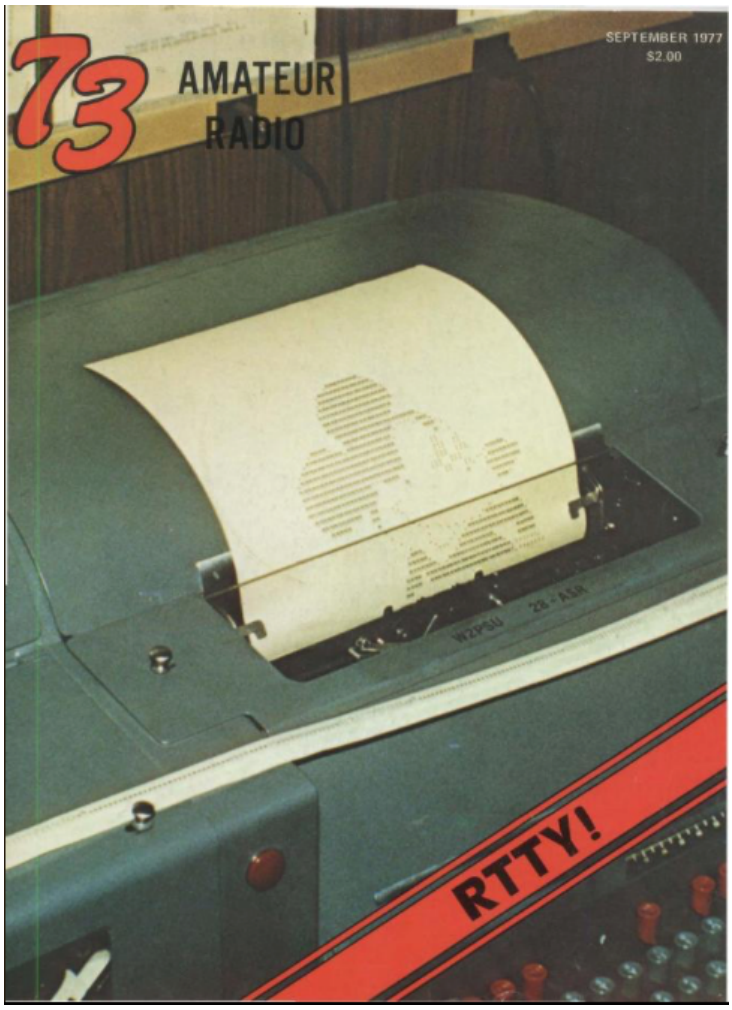
The code used is identified by two names, Murray and Baudot. From the latter, we get the term "baud," meaning bits per second (BPS). Common speeds for 5-level code teleprinters are 45 and 75 baud, which are often referred to as 60 and 100 WPM.

This 5-level code continues to be in use around the world today, not only within the confines of the amateur radio service, but with business communications through the Telex network and TTY terminals for the deaf and hard of hearing community.

RTTY (Radio TeleTYpe) hit the ham bands in the 1950s, as World War II surplus became available. Wayne Green W2NSD (SK) was a promoter of RTTY and deserves credit for much of the initial excitement and activity. He promoted the mode while editor of *CQ* magazine and in the pages of his own *73 Amateur Radio* publications.

While RTTY operation once meant large and noisy teleprinters in the ham shack – with the aroma of teleprinter grease and the oil used with paper tape – those days are almost totally in the past, as modern electronics and the "Glass Teletype" of computer displays have replaced the older technology.

Today, RTTY operation is a quiet affair—with "brag tapes" stored as computer files and RTTY contesting being



September 1977 issue of Wayne Green's 73 Amateur Radio magazine promoted amateur radio RTTY. (Courtesy: Archive.org)

more a matter of mouse clicks, than heavy typing. Also gone are the Terminal Unit (TU) interfaces, with audio filters for the "Mark" (2125 Hz) and "Space" (2295 Hz) tones, plus special-purpose oscilloscopes that displayed a perpendicularly-intersecting set of ellipses – when a signal was properly tuned in. With computers, RTTY is handled by computers with built-in sound card technology. Transceivers such as the Yaesu FT-991A allow for signals to pass via a USB connection – negating the need for an external audio interface, for setting levels.

When computers were first developed that could make use of a terminal, it was 5-level code teleprinters that filled the need. ASCII (American Standard Code Information Interchange) and the emergence of its 8-level code was still some time away. However, the higher speeds that the new ASCII-capable teleprinter allowed and the increased character set soon took over.

Early experimenters with microprocessors and microcomputers often turned to the older 5-level teleprinter models, as software could be used to handle the translation from one code to another and the cost savings were tremendous. The first printer I had on a microcomputer – in the mid-1970s - was a Teletype Model 15, which cost me a mere $15 when I got it at a local hamfest. With some time invested in what

would now be called a "driver" and a few parts to convert 5V TTL (Transistor-Transistor Logic) to a higher-voltage 60 mA current loop signal for the Model 15, I had a nice printer, with a savings of at least $900 – based on what used ASCII teleprinters were selling for at the time.

With the growth of microcomputers and their use in amateur radio, a desire to use these machines as "intelligent RTTY terminals" emerged. Certainly, it was easy enough to connect a computer through a TU and use 5-level code on the air, but what about ASCII? After some temporary authorizations, ASCII – with speeds up to 300 baud were allowed on HF. As the microprocessors in personal computers became faster and memory became less expensive, there were those who wanted to develop new forms of digital communications that improved upon RTTY as it was.

ASCII brought with it something called "parity," which assisted in error correction. If you used "odd parity," then the parity bit would be set to a "1" when the number of bits were of an odd number, but "0" if they were even. If you used "even parity," then the inverse was true. What was important was that everyone in the "circuit" used the same setting. If it was set to the opposite of what it should be, the data looked like gibberish. Still, parity was an improvement over what Baudot offered.

Before we get too far into the advantages of ASCII and the modes that would follow, there is another area where RTTY took off – that of VHF FM and the emerging world of repeaters. At the time, most repeaters were COR (Carrier Operated Relay) activated, in that all it took to light up a repeater was a signal that opened up the squelch circuit on the machine's receiver. With RTTY, we had KOR (Keyboard Operated Receiver) whereupon the repeater's receiver opened up upon hearing a signal with the Mark Tone. This was not dissimilar to CTCSS (Continuous Tone Carrier Sub-audible Squelch) with the exception that 2125 Hz is definitely in the audible range of most people's hearing.

Hams with RTTY stations on the repeater's output frequency would come alive when Mark was detected by their TUs. The teleprinter's motor would start to spin, in anticipation of printing out or punching some paper tape – based on the received signal that was almost always noise free. Just as 146.34 MHz (in) and 146.94 MHz (out) was the most popular frequency pair for voice operation, 146.10 MHz (in) and 146.70 MHz (out) was the most popular for RTTY operation.

When a RTTY-equipped ham got home from a day's work, he or she could literally "read the mail" and see what information had been passed during the day. If you didn't want to run through a roll of paper so fast, then there was SELCAL (SELective CALling) circuitry that might be wired in such a fashion as to not do anything, until it received your callsign or perhaps some preassigned alphanumeric code. After a set period of inactivity, a timer would reset the SELCAL.

In some areas, the repeater might cover a relatively small area with a handful of users, but in others, larger footprints and dozens of users was the norm. With the advent

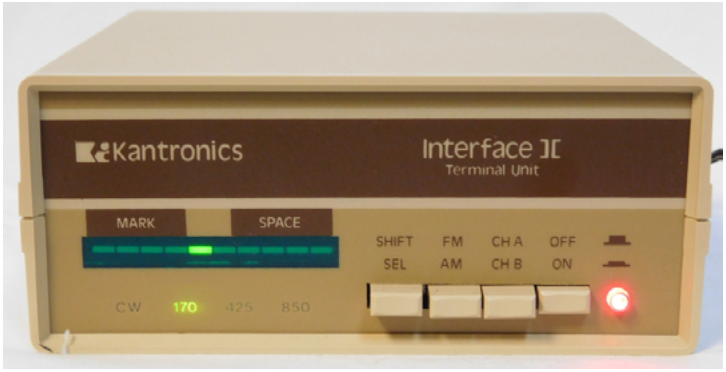
SWL software cartridge in vintage Commodore C-64 computer copying ARRL RTTY bulletin via HF July 2018. (KS4ZR photos)

of affordable personal computer systems, a BBS (Bulletin Board System) and individual mailboxes were established. If you wanted to download or printout some RTTY art of Snoopy, Santa Claus, or more – you could find it in the files of the BBS. Playing chess with another ham could be accomplished by leaving our move i.e. "BF5" or "Bishop to F5," using coordinate notation of the board.

Initially, such computer systems were expensive and assembled from numerous components, with high parts counts. As time went by, systems became less and less expensive, while costs decreased dramatically. I remember seeing a RTTY BBS in operation that was running on a Commodore VIC-20, which at one time could be found new in the box for well under $100.

The inception of BBS, mailboxes, selective calling, etc. are more associated with technologies that would come along with the advent of ASCII and subsequent modes, but it is important to know that these features were previously in place. What did happen is that the promotion and explosion of something known as Packet Radio incorporated these features. Since Packet Radio became more mainstream in the amateur radio community than RTTY, we tend to think of these innovations as something that were developed much later than they actually were.

Before we get into Packet Radio – more commonly



Two early popular digital interfaces. Left: The Hal CWR-6700 is a dedicated decoder for: Morse code, Baudot radioteletype at 45, 50, 57 and 75 baud and ASCII at 110 and 300 baud. The rear panel has RCA audio input from your receiver and output is composite video. Right: The Kantronics Interface II is a CW and RTTY computer interface. This device required computer-specific software. (Courtesy: Universal Radio)

referred to as simply "Packet" – let's explore what was going on in the world of HF digital communications. The allowance of ASCII on the ham bands brought about some notable improvements. Among those were higher speeds, increased character set – with lower case and special control characters – plus the easier interface and utility with microcomputers.

Special characters included WRU (Who aRe yoU), invoked as [CONTROL] + [E], ACK (ACKnowledgement of last group of data), NAK (No AcKnowledgement of last group of data – an invitation of retransmit again), WAK (Wait for AcKnowledgement – in case computer was too busy to immediately respond), XON (start/resume transmitting), XOFF (stop transmitting) and much more. While Baudot was typically sent blindly, without any sort of "handshaking" going on, ASCII was up to the task, especially in the half-duplex (only one station transmits at a time) world of ham radio.

Computers also brought about better error checking, such as checksum and CRC (Cyclic Redundancy Check) whereupon groups (packets) of data could be verified for accuracy. If a packet was OK, then an ACK was sent by the receiving station and the next packet could be transmitted. If a given packet was not OK, then a NAK was sent by the receiving station to ask for retransmission and so on. This involved some intelligence, but if the exchange was between two computers, that was easily accomplished. Now, not only could text-based RTTY art be sent without errors from noise, interference, or fading – small programs and data files could also be shared among hams at a distance.

AMTOR (Amateur Teletype Over Radio) was one of the technologies that used the above control characters, in pursuing error-free communications – with a method knows as "Mode B." Another way AMTOR could be used was by sending each character twice, as an ongoing direct comparison. For example, my callsign would be sent as "WWAA33UUVV." If the odd and even characters didn't match up, the receiving station knew something was wrong. The disadvantage of this method (Mode A) within AMTOR was that the effective data rate was cut in half.

As more of a footnote, high speed CW with redundant characters was also tried. Transmissions approaching one thousand words per minute could be obtained, but inevitable errors and recovery times brought that down to a much lower rate. Still, it was a valiant attempt to bring our original digital mode of communications into the digital world of microcomputers.

Elsewhere, a project called "AlohaNet" was underway. It combined much of the above, along with a variant of the X.25 networking protocols (AX.25) to create what would soon become the highly popular packet radio. Using the relatively inexpensive Bell 202 half-duplex Modem Standard tones of 1.2 kHz for Mark and 2.2 kHz for Space – plus the inclusion of an 8-bit microprocessor and firmware to run the application – the TNC (Terminal Node Controller) became part of the radio amateur's lexicon, seemingly overnight.

Although there was a TNC-1, it was the TNC-2 that occupied space in most ham shacks. With connections to a 2-meter FM radio's transmit audio, receive audio, and PTT (Push To Talk) lines – the TNC could be driven by a computer or dumb terminal – including an ASCII teletype, if desired.

To connect to another TNC, you simply typed "C KE8HTA" at the prompt and pressed [RETURN]. Instantly, the TNC would take over your radio, transmitting a packet to wake up the TNC at KE8HTA's station. Once accomplished, her TNC would transmit back and a connection was made. At that point, you could just start typing. With every press of the [RETURN] key, a packet was sent and acknowledged – unless there was a problem with the packet's data integrity, in which case a request to have it transmitted again would automatically be sent by KE8HTA's TNC.

If KE8HTA had her station on, but wasn't home, you could disconnect and then proceed to connect to her TNC's mailbox, leave a message and disconnect again. When she returned to he shack, she would notice that the "Mail" or "Message" LED was lit and could then check to see what mail she had.

If the two of you were too far away, but there was a

The PacComm TNC 220 is a Dual radio TNC. The rear panel features ports for two different radios and terminal connection. (Courtesy: Universal Radio)

commonly-accessible station in between, then you could use the "via" command to connect, such as "C KE8HTA v W3PIE." The "via" stations could be several, as long as you knew all of the respective call signs. They were able to do this when the other stations' TNC's had been configured as "digipeaters" or digital repeaters. Because the packets included metadata with callsigns, checksums, routing information, plus the actual data of your message – all was well.

With a TNC being driven by PBBS (Packet Bulletin Board System) software on a computer, messages could be routed around the world and stored at the respective "local" BBS – for retrieval at whatever time was appropriate. Using AX.25 addressing, your station might be identified as "WA3UVV @ W2MMD.#SNJ.NJ.US.NOAM". Broken down, that's your callsign @ the PBBS station's callsign, in an area or ARRL section, state / province, country, continent.

Behind the scenes, PBBS stations connected with routers – usually on 145.01 MHz – or perhaps higher-speed (up to 56 Kilobaud) routers on the 220 MHz or 430 MHz bands. Individual stations were usually on 145.03, 145.05, 145.07 or 145.09 MHz – along with their respective PBBS. In more populated areas, it was not uncommon for there to be one (or more) PBBS per county or parish.

Over a fairly short time, a totally volunteer network of amateur radio stations was established that spanned the globe. With a mix of HF, VHF, UHF and even some commercial transoceanic cable and satellite transponder connections, you could communicate textually with another ham almost anywhere.

As software had become available that could do at least a technical translation of one language to another – originally intended for business use – a ham in the States could talk back and forth with a ham in France, even though the French ham did not understand English and the US ham did not understand French. I had many "detached conversations" with foreign hams during this time – most of it by virtue of this merging of technologies. Today, I can just cut and paste text into Google's translate utility to accomplish the same thing.

This was all happening prior to and during the early days of the World Wide Web (WWW), at a time when most people would "discover" the Internet, through dial-up modems in the 1.2 to 14.4 kilobaud speeds. While the Internet also introduced the masses to TCP/IP (Transport Control Protocol/Internet Protocol) concepts and the now-familiar IP addresses like 192.168.1.1 – hams were already using TCP/IP with an offshoot of Packet Radio known as AMPRNet (AMateur Packet Radio Network) – which exists even today.

Within AMPRNet, IP addresses are in the 44 block – i.e. 44.65.2.60, which happens to be my address. For the digital experimenter there are many ways to enjoy what AMPRNet has to offer. It deserves some casual "poking around" at **www.ampr.org**.

While AMPRNet allows you to move around (physically) and still be able to access messages, Packet Radio's AX.25 addressing is better suited for static locations. This, and a desire to add some automated features and data passing, plus incorporate latitude and longitude coordinates – make easier with emerging GPS (Global Positioning Satellite) resources – motivated Bob Bruninga WA4PRS to conceive and design APRS.

Although APRS does not offer some of the advantages of good ol' Packet, it does represent advanced technology and continues to evolve and grow in both users and utility of value. The various characteristics, structure, requirements, and ways to make the most of this mode is coming up. Plus, we'll touch on some other advanced ways to pass data, such as Winlink, in Part II.

TSM

Kenwood TM-D710GA 144/440 MHz offers built-in GPS with 50/10/5 watts on both VHF and UHF. Features include an internal clock for APRS (Automatic Packet/position Reporting System) time and date stamp, APRS sort function, APRS filter function, APRS QSY function, APRS decay algorithm, APRS, proportional pathing, APRS voice alert, EchoLink ready, NOAA weather, 1000 memories and a sound card interface is built in. It lists for $700 but can be found at deep discounts. (Courtesy: Universal Radio)

APRS and Other Related Digital Communications – Part II

By Cory GB Sickles WA3UVV

In Part I (see *TSM* August 2018), we covered an overview of the history of digital communications in amateur radio leading up to APRS. All of the methods mentioned are alive and well with one exception—spark emissions. Spark remains the only mode ever used by hams that was outlawed, for good reason, in 1929. For what it is worth, there were those who were unhappy about it and who fought the new technology that replaced it—CW. History shows us that there have always been those who resist anything new and progressive, but change is inevitable.

Before we jump directly into APRS, there are a few more keyboard digital modes I should mention, as they are quite popular on HF and 6 meters. PSK-31 (Phase-Shift Keying at 31 bits per second) was developed as a weak-signal alternative to RTTY – which requires a stronger signal for it to be reliably decoded. PSK-31's much slower baud rate and narrower bandwidth allows it to function in situations where you might not be able to detect the signal by ear. Yet, reliable communications are possible, even with just a few watts. In fact, most PSK-31 (and the faster PSK-63) stations operate with no more than 20W. Higher power is unnecessary and widely discouraged.

PSK-31 is another mode that is made possible by use of the sound card interface found on every personal computer manufactured this century. The term "sound card" relates back to a time when this was an option that plugged into a desktop PC's expansion buss. It was the first exposure to DSP (Digital Signal Processing) technology, for most hams.

PSK-31 became extremely popular in a very short period of time. It also encouraged many to become hams – who had no interest in voice communications. I know of several radio amateurs whose HF activity is entirely non-verbal, nor are they active on CW. They prefer to communicate digitally with their keyboards and screens.

PSK-31 also brought us the term "waterfall," for the type of display that helps operators pick out various digital communications. It shows a narrow slice of spectrum within the audio passband and allows the software to tune in stations without touching the VFO knob on the transceiver. Small Wonder Labs, a producer of QRP (low power) transceivers for many years, made a 3W transceiver kit that was dedicated to PSK-31 operation on 80 meters. With just this

board, a dipole, some interconnecting cable, and the application running on an older laptop, you could work the world with a minimal investment.

PSK-31 was developed by Peter Martinez G3PLX in the 1990s. By using a variable-length character set, called Varicode, common letters might take up only two bits, while less common ones could be 10 bits in length. Not dissimilar to Morse code's variable-length character set, this helps to speed up effective transmission rates. Using lower case characters with shorter lengths also helps speed up PSK-31 transmission times.

As an offshoot of his work in astrophysics, Joe Taylor W1JT developed software for extremely weak signal work, for radio telescopes. Being a ham, Dr. Taylor realized that some of this research could be used for weak signal terrestrial communications, but additionally in the areas of EME (Earth Moon Earth) – more affectionately known as "Moonbounce."

WSJT-X (Weak Signal K1JT) is a suite of modes, including JT4, JT9, JT65, MSK144, WSPR, and others. The most popular of these is JT65 – for terrestrial communications – plus JT4 and JT9 for EME. MSK144 is used mostly at times when meteor showers ionize the atmosphere and allow for very short-duration, long distance VHF communications.

Most recently, FT8, a new weak-signal mode developed by Steve Franke K9AN and Joe Taylor, has become incredibly popular in a very short time. Its user base grew on 6 meters initially, then spread to HF. As with the other weak-signal modes, they present an advantage in making contacts, during times of low sunspot numbers and short-term propagation opportunities. The scope of any one of the aforementioned digital communications modes could fill pages, so I suggest you research these and possibly find something of interest to you.

APRS – as with Packet and AMPRNet – is not a weak-signal mode. However, since almost all APRS traffic takes place within the confines of 2 meters, it is a good set of tools for the average FMer. When most hams hear of APRS, they think of beacons and some sort of way to track high-altitude balloons or vehicles in a race or cross-country course. They may also think the "P" in APRS stands for "Position" – again referencing GPS-driven information in the data packets.

APRS is certainly useful for such applications, and radiolocation information is a key element in the foundation of the mode, but there are many more things that can be done with that information. While Packet used a variety of frequencies for terminal stations and network nodes, APRS uses but one per continent. In North America, that frequency is 144.39 MHz. This simplifies connectivity between stations, especially as many of them are in motion.

Almost all FM rigs can be used for APRS, however, there are some that are currently manufactured with APRS feature sets included. Alinco sells an TNC board (EJ-50U) option for their DR-635 dual-band radio. Kenwood offers the

Yaesu FT2DR provides sophisticated 2 meter/440 HT operation in traditional FM mode and C4FM FDMA digital modes. Offers built-in 66 channel GPS with antenna, 1200 bps/9600 bps APRS function, Dual watch (V/V, U/U/, V/U), Dual Monitor (C4FM Digital/C4FM Digital), GPS Logging/Recording capabilities, Water resistant (IPX5 Rating) and MicroSD Card Slot. (Courtesy: Universal Radio)

TH-D72A and TH-D74A portables, plus the D-710G mobile. Yaesu comes in with APRS built into the FT2DR portable, plus the FTM-100DR and FTM-400XDR mobiles. APRS works more smoothly with dual-band, dual-VFO transceivers, so you can have APRS running on VFO B, with voice communications on VFO A. Note that Kenwood's TH-D74A also includes D-STAR DV (Digital Voice) capabilities. While Icom's recent D-STAR models do offer GPS receivers for DV use, they do not currently offer anything with true APRS functionality in the radio. More on that, coming up.

Previously produced portable radios that you might find for a good price include the Kenwood TH-7 and Yaesu's FT1, VX-8GR, or VX-8DR. Previously-owned radios show up at hamfests and on-line auction sites, with most of them in rather good shape. They tend to hold their value, but some bargains can be had, if you are an informed and prudent shopper. I try to spend no more than 60 percent of the close-out price, since there is no warranty. On the positive side, such radios are often packaged with accessories such as drop-in charger cradles, speaker microphones, programming software and spare batteries—which does increase the value of such a purchase.

No matter whether you opt for new or used, do some research first, to see what features are offered in each model and what you feel to be the best value. I have mentioned in

This Kenwood TH-D7AG is a dual band HT for 2 meters and 440 with up to 5 watts on each band. It features a built-in TNC (1200/9600) as well as APRS. This model has long been discontinued but can be found used. This one recently sold at Universal Radio for $120. (Courtesy: Universal Radio)

previous columns how thankful I am for Universal Radio and their willingness – for the overall good of ham radio – to keep discontinued model specifications and features on their web site.

For example, entering "Universal Radio Kenwood TH-7GA" will display a link for that product page and a wealth of information. This has proven to be an excellent resource to me, time and time again. They also sell a significant amount of used gear, so also check the links and see if they have what you are looking for, in stock. This is one of the few places that does offer a warranty on used gear—another value-added service.

I do wish that there was an "APRS Bible" or "APRS for Dummies" sort of book out there that was an all-encompassing guide to this mode. Sadly, there is not. Hopefully, one will appear on the market soon, as I believe this would create a substantial increase in APRS activity.

I wish I had the resources to create such a text, but a lack of time makes that prohibitive. Also, I'm not at all too certain that I know enough to adequately write a complete guide. The more I look into APRS, the more I find I need to learn. With all of that in mind, let us begin to explore this exciting mode.

One of the first things you will want to know is how popular APRS is in your area. Whereas Packet Radio activity was spread from 145.01-147.09 MHz, APRS activity in North America is found on just one spot in the 2-meter band: 144.39 MHz. Tuning a radio here and listening for telltale short bursts of data, will give you a rudimentary idea of how much local activity there is and how strong those signals are. Another way is to point your web browser to **www.aprs.fi** and then observe the information on the map that is displayed.

If your ISP (Internet Service Provider) is up to date, you should see your position in the center. Hopefully, you will also see a healthy number of stations nearby. If not, expand out a bit and more stations should appear. Look for icons that denote mobile or portable or fixed operations, along with weather stations. Clicking on a particular station will show line segments that denote the pathway that signals take to the next digipeater or iGate—a connection point between RF and the Internet. The network of iGates (Internet GATEway) is what helps to drive the information shown on the map.

One additional thing to note is that recent-model D-STAR radios (early models did not support internal GPS technology) will also show their position through a data packet format translation resource known as D-PRS. D-PRS is not the same as APRS, in that all it does is report that radio's position. However, it does make D-STAR the only DV methodology that currently reports this information in this format—through the methodology.

If you see stations relatively close to you, a portable radio is probably fine for your first APRS station. If they are a bit further away, then a higher-power mobile rig and gain antenna may be required. Once you have a high-power node set up and configured to digipeat, low power portable stations can communicate through it, to get to the rest of the network.

Specific configuration of transceivers with APRS features built-in will be found in the respective product manuals. Some manufacturers offer additional APRS-specific supplements that are downloadable from their web sites. I strongly suggest you review this information BEFORE you begin to configure your radio. Having a better knowledge of what is required and where to find it, makes the configuration process go much more smoothly.

Radios such as the Kenwood TH-D72 have free programming software available for downloading from the manufacturer. While I found the MCP-4 software to make programming and parameter setup much easier than through the front panel, I feel that downloading **RT Systems**' KRS-D72 software is worth the additional $25, given what it offers.

Yaesu offers the ADMS-8 program to setup the features of the popular FT2DR portable, which offers APRS, along with System Fusion digital voice. Both Kenwood and Yaesu include the necessary cabling with the radios, eliminating the need for an additional purchase.

Common to your radio, you will need to specify your callsign, along with an SSID (Secondary Station IDentification) which typically ranges from 0 to 15. If you are con-

FTM-400XDR is the same as the FTM-400DR but with an improved GPS receiver. This 2-meter/70-cm offers 3.5-inch TFT color display; 5/20/50 watts; APRS and much more. It lists at $910 but is deeply discounted to $429 at Universal Radio through 1/31/2019. (Courtesy: Universal Radio)

Out of this world digipeater: The International Space Station (ISS) digipeating on 145.825 MHz. You'll have to be quick to use it, at 17,000 mph, you won't be in its footprint long. (Courtesy: NASA)

figuring a home station, then your SSID will be -0, which means you don't need to specify it. Thus, my home station – incorporating a Yaesu FTM-400 - is simply WA3UVV. If you have a digipeater in operation, then an SSID or -1 or -3 is common. An SSID of -5 denotes an iGate, while -7 indicates that you are operating portable. Full lists can be found on various APRS web sites, but these are the most popular.

You will also want to set your radio to beacon mode periodically, letting others know that your station is on the air. A feature known as "Smart Beaconing" is very strongly suggested. Instead of a fixed interval between beacons, your speed and position changes determine how often you transmit. If you are not moving or walking, you don't need to update your information as often as you do when traveling down the Interstate. This cuts down on unnecessary traffic, which is a very desirable thing.

Imagine an event where the use of APRS trackers and dynamic positional data for the head and tail of a bike race peloton, along with occasional text messages are being passed. All it takes is one or two fixed checkpoint stations burping out beacons every minute – essentially announcing "I am still where I was one minute ago" – to create data collisions and loss of efficacy in keeping event organizers from taking full advantage of what you are offering through amateur radio.

You can create and select from various beacon messages. Initial messages often let others know what city and state you are in, plus your email address, especially if you are looking for reception reports.

While you are driving, your beacon can let receiving stations know that you are listening on a specific simplex frequency (such as 146.52 MHz) or repeater. The use of a CTCSS tone of 100.0 Hz allows stations to exchange short voice messages to make contact, then move to another frequency.

Other pre-loaded text messages can come in handy with EMCOMM or public service events. Messages such as "On station," "Moving to new location," "Taking a break – be back in 5 minutes," "Ending operations," "Yes," "No" and so on, are common and keep routine traffic from taking up time on a designated voice channel, while allowing you to transmit the information immediately, instead of waiting for a break in voice communications.

Sending a short email message is another feature of APRS that can come in handy. With my FTM-400, I can use the color touch screen to enter the APRS menus, enter the callsign of the destination station, enter the message and send it, in less than a minute – once practiced at it. Should a return email be sent, an alert on my radio will let me know there is something for me to see.

Terrestrial paths are not the only way to go. APRS satellites, including the International Space Station, can be thought of as very high altitude and large footprint digipeaters. While the ISS's station has exhibited some hardware issues lately, they seem to have magically disappeared and all is well again. AMSAT has been busy working toward the ongoing goal of getting other satellites into orbit, including those that support APRS. Some research time invested at **www.AMSAT.org** will reward you with the frequency and operational specifics, along with info on other satellites that you might find to be of interest.

A little closer to home, high altitude "Balloonsats" are often launched and float to upwards of 100,000 feet (30+ kilometers) for hours. While APRS digipeaters are less common, locators are usually part of the payload, as they provide tracking data, in the form of latitude, longitude, altitude and perhaps more. As important as this is while in the air, it is certainly important when trying to locate the package once it

has landed.

Back on the ground, APRS is a good way to let other hams know that you are in range of them and desirous of a voice conversation. With a feature known as Voice Alert, you can include in your beacons some information about what frequency you are monitoring. With the use of sub-audible tone squelch set to 100.0 Hz, other hams receiving your signals can call you (with a 100.0 Hz tone enabled on their radio, of course) to hold a brief exchange that suggests a different frequency to move to. Alternately, your beacon could include the other frequency where your second VFO is already tuned.

This sort of "pinging" can be a much smoother and rewarding approach than simply transmitting a call on 146.52 MHz as you drive along an Interstate or other highway. It also has worked well for me as I enter a new town where APRS activity is evident.

To further assist the traveling ham, Frequency Alert is another feature that can be used to indicate what repeaters are in the area and which ones support various DV methodologies. Inclusion of an organization's web address can also be a good pointer for them to get additional information – including meeting times and details on lunch meetings or other activities.

If you have a portable radio (FT2, TH-D72, etc.) then it is easy, once configured, to just drop it in the car. As with voice operation, your coverage is not going to be the best, when using such a handheld radio inside of your vehicle—especially with the typical "rubber duckie" antenna. It is amazing just how much your coverage increases, when you incorporate a proper mobile antenna. Just one watt and a magnetic mount quarter-wave antenna on the rooftop, will outperform five watts and a duckie.

Powering the radio through your car's electrical system lets you run longer, as well. If your travel to some hamfests in your area, be on the lookout for small and inexpensive used 2-meter amplifiers that can take in anywhere from one to five watts and deliver 20 to 45 watts out. Some may even include a preamplifier, which helps with further increasing your receive range. Over the years, I have picked up several—usually in the $20 to $30 range. Placed under a seat, you have the advantage of more power and the ability to take your radio out of the car; becoming less attractive to thieves.

My typical "APRS to Go" setup is a Yaesu FT1DR, 25-watt Radio Shack amplifier and quarter-wave magnetic mount antenna. Rounding things out is a set of adapter cables that power the radio and amplifier from the power port (formerly known as a cigarette lighter) plus a speaker-microphone. Through another hamfest acquisition, I have a Kenwood speaker/mic with a volume control and adapter cable to fit my Yaesu. Everything in this mini-Go Kit was purchased used or put together from parts. If I total up my costs, I'm looking at just under $200. That's not too shabby for a decent mobile setup – one that features APRS.

Weather stations are another resource that is popularly integrated into the APRS network. Many of us who are

The sky's the limit on the amount you can spend on a home weather station. To make it useful for other hams and to join online weather networks make sure it is capable of doing so. (Courtesy: Davis Instruments)

SKYWARN weather spotters have modern ways to monitor and report temperature, humidity, wind speed, wind direction, rainfall, and more. Weather stations with communications ports can be interfaced with APRS stations, providing such information to others in the surrounding area.

I also use my home APRS station to show when there are band openings. The number of beacons and messages that show up on my heard list is usually comprised of a local collection of callsigns. However, when the band is experiencing some enhanced propagation, I get to see unfamiliar callsigns in the list. Tapping on the entry with my FTM-400, I find stations from hundreds of miles away.

As a reminder, I live in southwestern Pennsylvania. So, when I see fixed stations in Indiana, South Carolina, New Jersey, Vermont, Quebec, or Ontario—it is a cause for celebration. It is also a good indicator that it would be a good time to explore some weak-signal work around 144.200 MHz and higher bands.

APRS is a versatile mode with many aspects that are of value to the radio amateur. Hopefully, I have given you some ideas about what you can do with it, as well as other non-verbal digital communications. APRS does not require a major investment to get started. You may already have most of the hardware required. From a small setup with a portable and smartphone, to a more extensive station with weather capabilities, APRS can be fun and useful, once you give it a try.

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